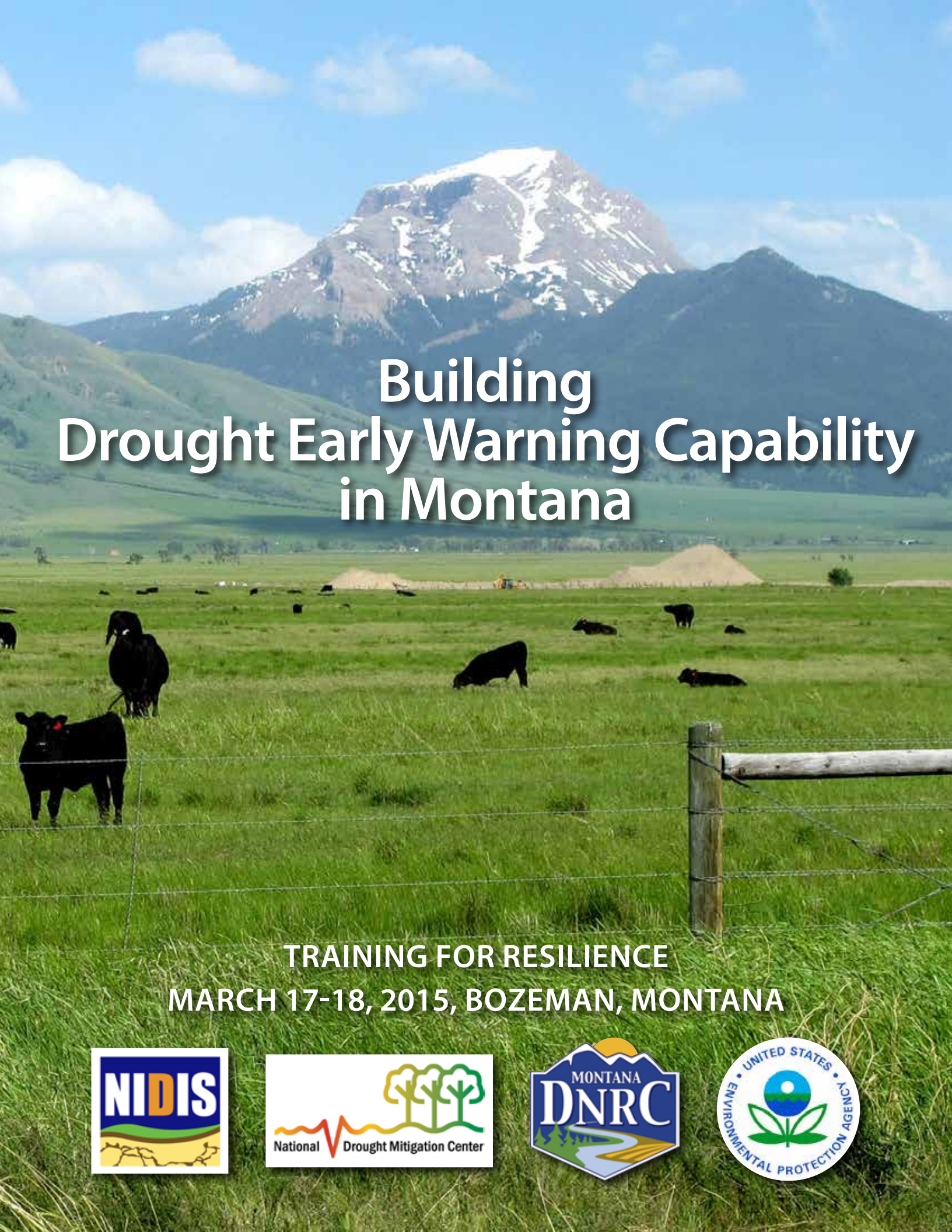


Building Drought Early Warning Capability in Montana

TRAINING FOR RESILIENCE

MARCH 17-18, 2015, BOZEMAN, MONTANA

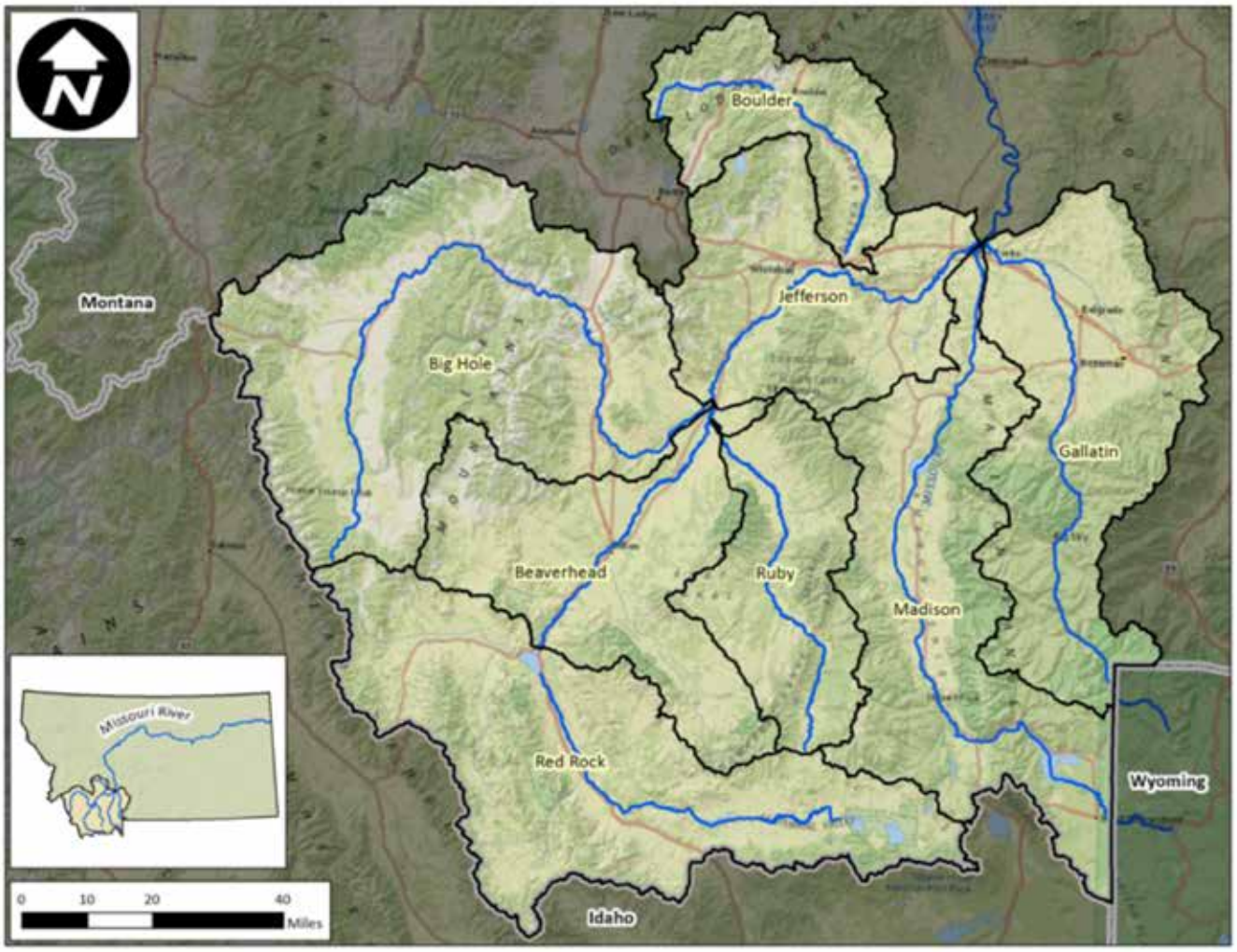
NIDIS

National Drought Mitigation Center

MONTANA DNRC

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

Building Drought Early Warning Capability in Montana



Map of the Upper Missouri River Basin, which was geographical region of focus for the meeting.

Sponsors

- NOAA's National Integrated Drought Information System (NIDIS)
- The National Drought Mitigation Center (NDMC)
- Montana's Department of Natural Resources and Conservation (DNRC)
- The Environmental Protection Agency (EPA)
- The effort helped support activities for the NIDIS Drought Early Warning System in the Missouri Basin, as well as functioning as a demonstration project for Montana announced by the National Drought Resilience Partnership (NDRP).

INTRODUCTION

Ivan Doig wrote, "We count by years, but we live by days." This is an analogy to droughts, in that we tend to think about them as singular events, yet we experience them by degrees, as they evolve, usually over an extended period of time. Droughts are a normal part of the climatic cycle and can occur in any climate regime around the world, including deserts and rainforests. It can be difficult to determine when they begin and when they end, and their impacts can extend over a larger geographical area compared to other natural hazards. Environmental changes involving incremental and cumulative problems usually receive little attention in their early phases, as decision and policymakers choose to deal with more immediate concerns. If these creeping events go unaddressed they can eventually become crises that are more costly to manage. A drought should never surprise anyone, yet it often does.

The Upper Missouri Basin in southwestern Montana has experienced frequent droughts. It is composed of the Madison, Gallatin, and Jefferson Rivers and their tributaries. Their confluence of the three rivers at Three Forks, Montana, forms the headwaters of the Missouri River. The Upper Missouri Basin is a mix of agricultural lands, scenic rivers with an active trout fishing industry, resorts, and a growing urban area in Bozeman. Each sector has unique needs and the desire to grow and sustain its activities. Ownership of land in the basin is a combination of private, state, and federal. Most lowlands are privately owned, while the U.S. Forest Service (USFS) or the Bureau of Land Management (BLM) administer most of the higher elevations.

THE WORKSHOP

On March 16-17, 2015, a workshop in Bozeman, Montana, brought together participants from across the Upper Missouri Basin to discuss ways to improve drought early warning and drought resilience. The participants came from seven sub-watersheds, which included the Beaverhead, Ruby, Big Hole, Upper Gallatin, Lower Gallatin, Madison, and Jefferson Rivers. The national Oceanic and Atmospheric Administration's (NOAA's)National Integrated Drought Information System (NIDIS), the National Drought Mitigation Center (NDMC), the Environmental Protection Agency (EPA), and Montana's Department of Natural Resources and Conservation (DNRC) hosted the meeting. The effort helped support activities for the NIDIS Drought Early Warning System in the Missouri Basin, as well as functioning as a demonstration project for Montana announced by the National Drought Resilience Partnership (NDRP). Over the course of the workshop, participants from the sub-watersheds examined tools that could be used to develop or strengthen watershed-specific drought plans. In addition to the overarching theme of drought, the workshop highlighted the opportunity to develop broader water management plans to reflect water shortages even in non-drought years.

Workshop participants gathered at tables set up for each of the headwaters areas.

The workshop was designed to bring together watershed-based "teams" that could initiate a conversation with the community on managing scarce water resources and preparing for future drought conditions. Workshop facilitators from NIDIS and the NDMC led the group in a step-by-step drought planning process using tools, such as the Drought Impact Reporter, the Drought Risk Atlas, and the Drought-Ready Communities guide, to track conditions, identify triggers and work through potential conflicts between water users. The diverse group of participants included Big Sky Watershed Corps (BSWC) AmeriCorps members, watershed coordinators, state and local agencies, city planners, agricultural producers, land trusts, conservation districts, NGOs, hydrologists, and local federal partners.

Agenda

DAY 1: Identifying Impacts, Risks, Vulnerabilities, and Drought Monitoring Resources

- Overview of Drought Planning and Risk Management
- Identifying Drought Planning Resources
- Introductions to NDMC, NIDIS and the Missouri Basin Regional Drought Early Warning System; Montana State Drought Plan, Drought Advisory Committee and State Climate Office
- Identifying and Assessing Your Impacts and Vulnerabilities: The Drought Impact Reporter (http://droughtreporter.unl.edu/)
- Identifying Your Drought Risk: The Drought Risk Atlas http://droughtatlas.unl.edu/)

DAY 2: Framing a Plan

- Drought Monitoring and Early Warning Resources: The U.S. Drought Monitor and other tools
- Identifying Monitoring and Early Warning Needs
- Framing Your Drought Plan
- Identifying Opportunities for Implementation of Mitigation Strategies
  - How to Implement Your Plan

Participants

- Big Sky Watershed Corps (BSWC) AmeriCorps members
- Watershed coordinators
- State and local agencies
- City planners
- Agricultural producers
- Land trusts
- Conservation districts
- NGOs
- Hydrologists
- Local federal partners

Representatives came from seven sub-watersheds of the Upper Missouri Basin, which include the Beaverhead, Ruby, Big Hole, Upper Gallatin, Lower Gallatin, Madison, and Jefferson Rivers.

About the pre-workshop survey

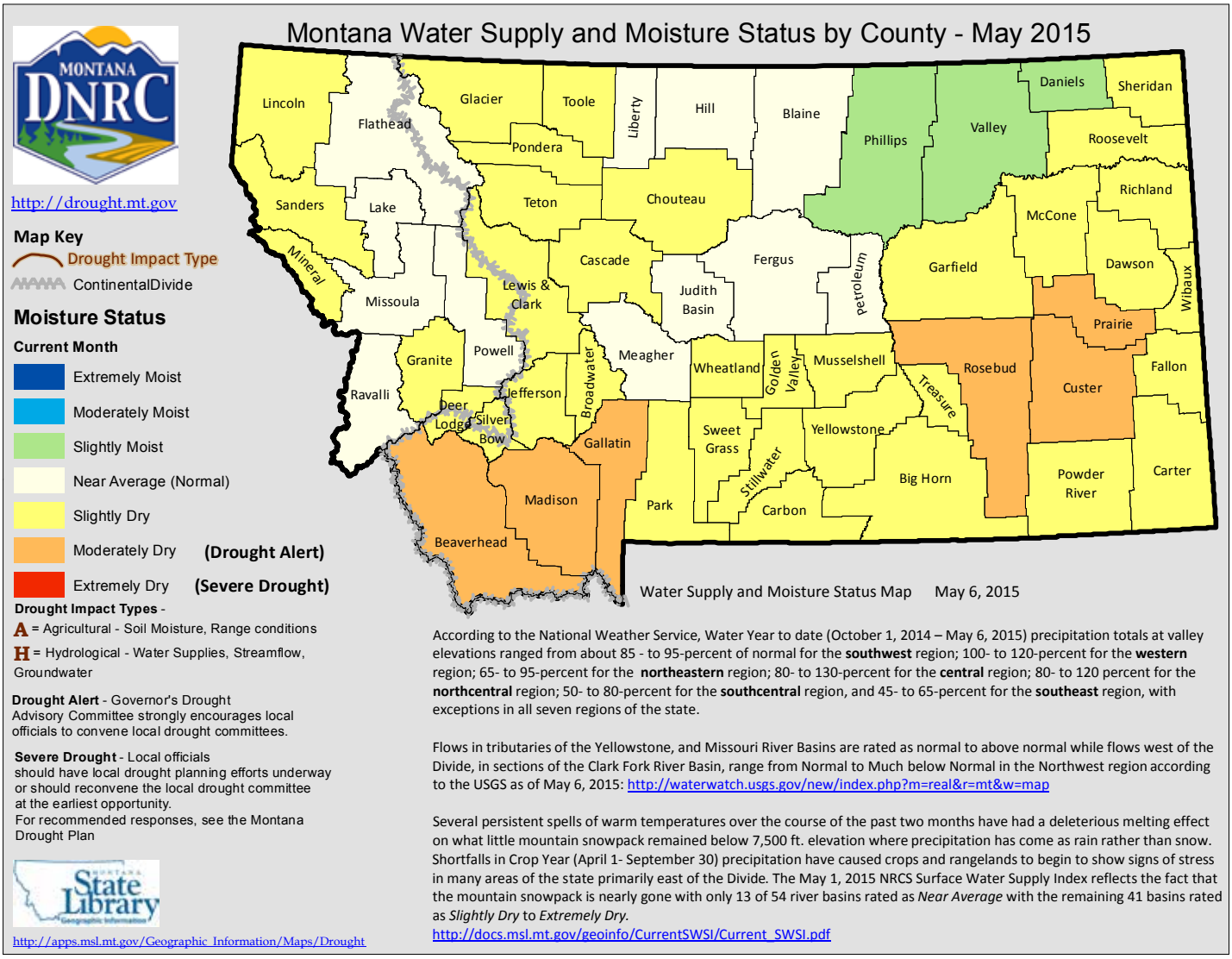
Before the workshop, a survey was sent to all of the expected participants. The results guided the workshop agenda and informed the discussion questions. Excerpts from the results appear as sidebars in this document.

A post-workshop survey was also conducted to assess the applicability of the material presented, what the participants learned at the workshop, and how the information would be applied in their respective watersheds. A summary of the findings is presented on pages 18-19.

MONITORING AND FORECAST GROUPS AND RESOURCES

The first part of the workshop consisted of describing existing resources available for observing, monitoring, and forecasting conditions related to drought. Four organizations were highlighted that either produce or help consolidate the data and information related to drought monitoring and early warning. Specific examples of data products were given in the context of each group. The organizations were:

- **The National Integrated Drought Information System** (NIDIS) is an interagency federal program created by Congress in 2006 to develop a drought early warning system (DEWS) for the U.S. NIDIS is working toward its national goal by establishing a network of regional DEWS (RDEWS). These RDEWS build on existing monitoring and forecast products and service networks like the U.S. Drought Monitor (USDM) and seasonal outlooks (e.g. the National Weather Service's Climate Prediction Center 90-day



According to the National Weather Service, Water Year to date (October 1, 2014 – May 6, 2015) precipitation totals at valley elevations ranged from about 85 - to 95-percent of normal for the **southwest** region; 100- to 120-percent for the **western** region; 65- to 95-percent for the **northeastern** region; 80- to 130-percent for the **central** region; 80- to 120 percent for the **northcentral** region; 50- to 80-percent for the **southcentral** region, and 45- to 65-percent for the **southeast** region, with exceptions in all seven regions of the state.

Flows in tributaries of the Yellowstone, and Missouri River Basins are rated as normal to above normal while flows west of the Divide, in sections of the Clark Fork River Basin, range from Normal to Much below Normal in the Northwest region according to the USGS as of May 6, 2015: http://waterwatch.usgs.gov/new/index.php?m=real&r=mt&w=map

Several persistent spells of warm temperatures over the course of the past two months have had a deleterious melting effect on what little mountain snowpack remained below 7,500 ft. elevation where precipitation has come as rain rather than snow. Shortfalls in Crop Year (April 1- September 30) precipitation have caused crops and rangelands to begin to show signs of stress in many areas of the state primarily east of the Divide. The May 1, 2015 NRCS Surface Water Supply Index reflects the fact that the mountain snowpack is nearly gone with only 13 of 54 river basins rated as *Near Average* with the remaining 41 basins rated as *Slightly Dry* to *Extremely Dry.*
http://docs.msl.mt.gov/geoinfo/CurrentSWSI/Current_SWSI.pdf

The Water Supply and Moisture Status Map is a key index for the Montana Governor's Drought and Water Supply Advisory Committee. It is produced by Committee and published by the Montana State Library. The library also archives the maps back to 2002: http://mslapps.mt.gov/Geographic_Information/Maps/drought/

seasonal outlook) to provide improved communication and coordination of monitoring, forecasting, and impact assessment at national, watershed, state and local levels. One example of this work is the Missouri River Basin RDEWS (http://www.drought.gov/drought/regional-programs/mrb/missouri-river-basin-homee) that was initiated in early 2014 and encompasses the watersheds that participated in this workshop. NIDIS is housed within NOAA.

- **The National Drought Mitigation Center (**NDMC) established in 1995, is based in the School of Natural Resources at the University of Nebraska-Lincoln. The NDMC's activities include the production of drought monitoring information and products. For example, NDMC, along with NOAA, and the U.S. Department of Agriculture (USDA), lead the preparation of the U.S. Drought Monitor (USDM). The NDMC has also developed the U.S. Drought Impact Reporter and the Drought Risk Atlas (both described below); a suite of web-based drought management decision-making tools; drought planning and mitigation guides; K-12 outreach; and helps organize workshops for federal, state, foreign governments and international organizations.
- **The Governor's Drought and Water Supply Advisory Committee** was established by an act of the Montana State Legislature (MCA Sec. 2-15-3308 Drought Advisory Committee) in 1991 following a series of drought years in the 1980s. The primary purpose of the act was to create a state drought advisory committee composed of state, local, and federal officials who could consistently monitor water supply and moisture, and help inform response actions to reduce drought impacts. The Drought Advisory Committee consolidates water supply and moisture information on a monthly basis for state and local agency officials with responsibility to manage natural resources and support constituents most likely affected by drought. It also does a monthly assessment of forecasts (precipitation/temperature), mountain snowpack, streamflow, soil moisture, reservoir status, and agricultural and livestock production. The committee is charged with developing a state drought plan, and provides planning support and information sharing with watershed groups and county drought committees through its website and staff.
- **The Montana Climate Office** was designated in 2006 as the official steward of climate information and services for the state of Montana, maintaining climate station data for the state, and assisting stakeholders in interpreting climate information or adapting climate products to their needs. Some of their current datasets include:
  - -- Gridded precipitation
  - -- Gridded temperature (min, mean, max)
  - -- Normalized Difference Vegetation Index (NDVI)
  - -- Enhanced Vegetation Index (EVI)
  - -- Evapotranspiration (ET)
  - -- Potential evapotranspiration (PET)
  - -- Drought Severity Index (DSI)
  - -- Source datasets for all of the above and additional Montana Climate
  - -- Office resources

From the pre-workshop survey

What are you hoping to learn from the workshop on Building Drought Early Warning Capacity in Montana?

- Rather than learning short-term annual warnings about drought, I hope there is some discussion of long-term measures to adjust to reduced water supplies.
- Hoping to bring back some tools to better assist my field office in drought years. And to help make our watersheds even more drought resilient.
- Useful information, in lay people's terms, on why it is important, how to convey information and solutions to share with my stakeholders
- A template to begin working on a drought plan
- New tools / strategies / funding sources for drought resilience / preparedness
- I was not in a water leadership position during any previous severe droughts. I am hoping to learn effective tools for communicating and decision-making, along with any other information I can!
- I'm hoping to get a better understanding of the drought related work that others are doing around southwest Montana.
- How can global atmospheric and oceanic circulation patterns help create climate outlooks in southwest Montana? Are there new/emerging monitoring tools that we should know about? How can we use a suite of early warning tools/info to give the community a more complete picture of how drought is affecting our area?

From the pre-workshop survey

What critical impacts could be reduced?

- Efficient shared water use could mitigate some impacts
- Impacts to riparian areas as well as uplands from livestock grazing
- Agriculture, fisheries, and public water interests could mitigate some impacts with early planning.
- We might be able to avoid total dewatering of the stream. Just to maintain survival flows for the resource during the critical years would be a success. Increasing the resiliency of agricultural producers would be another way to reduce impacts.
- Impacts to those reliant on crop production could be reduced as they could plan more drought tolerant crops for the affected growing seasons. Impacts in the wildland urban interface could potentially be reduced as resources could be directed more heavily to education/prevention of those effects. Municipal water suppliers could be better prepared and enact measures to further conserve water. Dam managers could also be prepared and maximize storage.

DROUGHT INDICES

The US Drought Monitor

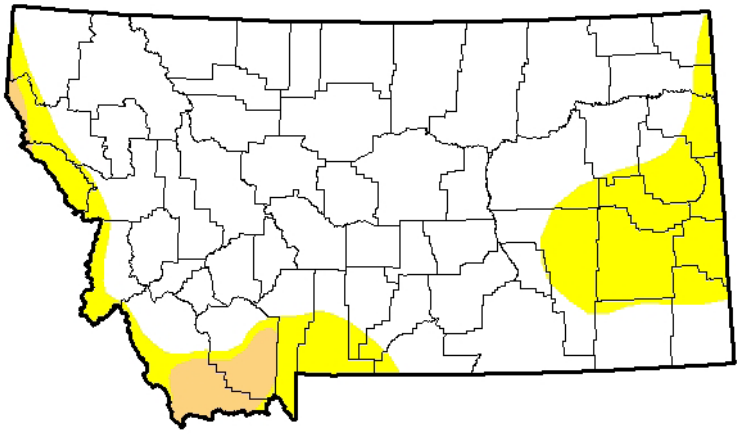
Given the typically slow onset of drought and its complexities, it lends itself quite well to using indicators and indices to predict and monitor its progression. One of the primary composite indicators used to monitor drought in the U.S. is the U.S. Drought Monitor (USDM) which has been produced weekly since 1999.

There are four basic drought perspectives: 1) meteorological; 2) agricultural; 3) hydrological; and 4) socioeconomic, and there are indices and indicators associated with each. No one index or indicator adequately describes all aspects and types of drought. In developing its weekly map, the USDM integrates multiple data sources and derivative products from local to national scales, and incorporates feedback and input from an expert user group of more than 350 people from across the U.S.

For agricultural producers, the USDM is used as a trigger to initiate and/or terminate several programs in USDA's Farm Service Agency (FSA). FSA uses the USDM to identify areas eligible for emergency haying and/or grazing support through the Conservation Reserve Program, as well as grazing losses due to drought under the Livestock Forage Disaster Program (LFP). The Internal Revenue Service is also using the USDM for tax deferrals for livestock producers who involuntarily sell livestock due to drought conditions. Montana participates in the development of the USDM through a coordinated weekly process lead by the National Weather Service's (NWS's) Great Falls Weather Forecast Office.

U.S. Drought Monitor

Montana



May 19, 2015

(Released Thursday, May. 21, 2015)

Valid 7 a.m. EST

Drought Conditions (Percent Area)

	None	D0-D4	D1-D4	D2-D4	D3-D4	D4
Current	78.75	21.25	2.97	0.00	0.00	0.00
Last Week 5/12/2015	67.08	32.92	2.90	0.00	0.00	0.00
3 Months Ago 2/17/2015	96.52	3.48	0.00	0.00	0.00	0.00
Start of Calendar Year 12/30/2014	98.84	1.16	0.00	0.00	0.00	0.00
Start of Water Year 9/30/2014	91.25	8.75	1.25	0.00	0.00	0.00
One Year Ago 5/20/2014	98.75	1.25	0.00	0.00	0.00	0.00

Intensity:

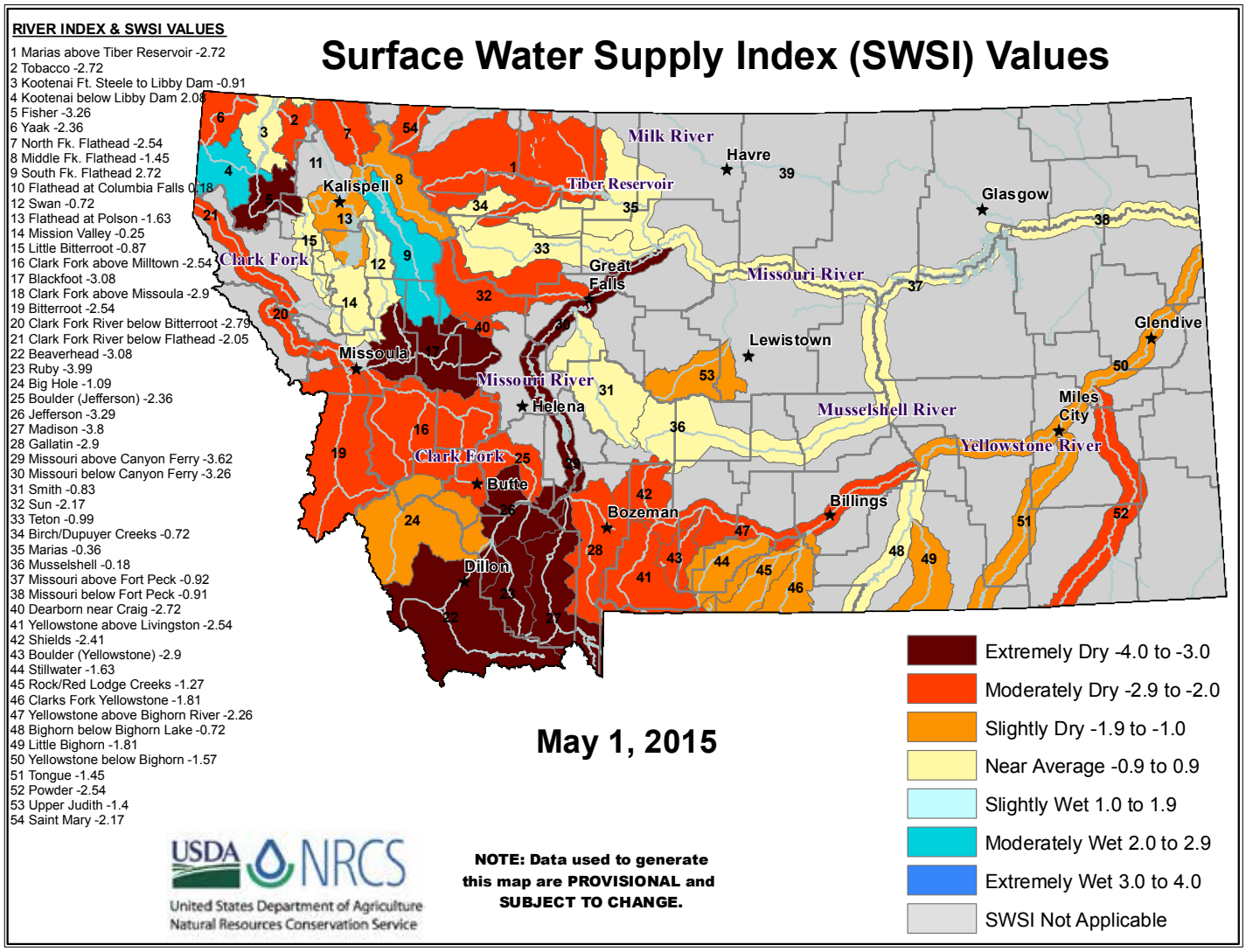
- D0 Abnormally Dry
- D1 Moderate Drought
- D2 Severe Drought
- D3 Extreme Drought
- D4 Exceptional Drought

The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. See accompanying text summary for forecast statements.

Author:
Brad Rippey
U.S. Department of Agriculture

http://droughtmonitor.unl.edu/

The status of drought in Montana as depicted by the U.S. Drought Monitor (USDM) for the week of May 19, 2015. The USDM is updated every Thursday morning. The date of the map reflects the cut-off date (Tuesday preceding the update) for new information to influence that week's update.



Montana's Drought Advisory Committee also uses several other indices. These include the Surface Water Supply Index, pictured above, and the Montana Water Supply and Moisture Status by County (pictured on page 4).

As the name implies, the Surface Water Supply Index (SWSI), pictured above, is an indicator focused on the status surface water supply. The index takes into account snow melt/snowpack, mountain precipitation, streamflow, reservoir storage, and soil moisture conditions. SWSI maps and reports are available for each month from January through October beginning in 1992 on the Montana State Library website: http://mslapps.mt.gov/Geographic_Information/Maps/watersupply/SurfaceWaterSupplyIndex/Default.aspx

ASSESSING IMPACTS AND VULNERABILITIES

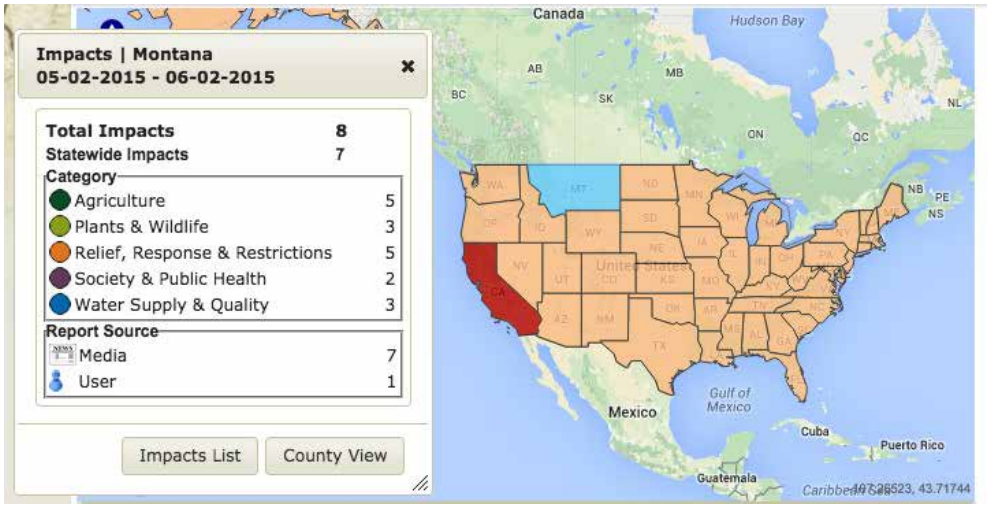
Having an early indication that drought will develop or intensify is critical to employing strategies that can mitigate and reduce the impacts. A simple definition of drought could be "insufficient water to meet demand." Demand can be based on instream flows for a healthy functioning ecosystem or on institutional and economic systems linked to human health and welfare. When there is not enough water or moisture to meet demand, impacts begin to emerge. Understanding demand and impacts is critical for systems designed to provide early warning of drought.

During the meeting, the NDMC Director Michael Hayes stated, "You cannot manage what is not monitored." To manage drought you have to monitor impacts and understand vulnerabilities or the consequences of those impacts.

From the pre-workshop survey

In your watershed, do you think vulnerability to droughts has been increasing, decreasing, or remaining the same and why?

- Increasing. Because the land resources are experiencing a cumulative effect from past drought years. For instance, native bunch grasses are more susceptible to drought because due to previous drought years their vigor is low, with each additional drought year the plant begins to die off.
- In the Dillon BLM Field Office I think vulnerability to drought has been decreasing due to good land health management, which is increasing drought resiliency.
- Decreasing due to the development of our Drought Management Plan, but I'm nervous about the upcoming water year after this relatively dry winter.
- I think vulnerability to droughts is increasing on public lands because the agencies have an inability to act in a timely manner; on private lands because of an inability to see the need for adaptability planning and prevention. We are fortunate to have active, effective voluntary drought management plans that have proven to work well, but I see that as a Band-Aid for temporary conditions, not long term planning for the future.
- Increasing vulnerability. More people, more water hungry crops, chasing greater yields and larger cattle, all require more water. Continuing decline in soil organic matter leading to less water holding capacity. Increase in irrigation efficiency and well drilling reducing ground water supplies with no understanding of recharge rate/dynamics.
- Vulnerability decreasing due to improved watershed coordination.
- In the Gallatin Valley, I think our vulnerability to drought has been increasing. The population is expected to triple by the end of the century, and this will create a tension between municipal and agricultural water users. Drought will only compound this issue.



The Drought Impact Reporter can be displayed across a variety of temporal and spatial scales and by sector category. Users can also specify impacts by reporting source.

Drought Impact Reporter

The NDMC launched the Drought Impact Reporter (DIR): http://droughtreporter.unl.edu/ in 2005 as the nation's first comprehensive database of drought impacts. The DIR is a web-based mapping tool designed to compile and display impact information from the media, government agencies, and the public across the U.S. in near real-time. Each of these sources provides different types of information at different spatial and temporal scales. One of the unique aspects of the DIR is that private citizens can submit drought impacts: http://public.droughtreporter.unl.edu/submitreport/

There is also a Drought Impacts RSS feed which displays impacts as they are posted: http://moderator.droughtreporter.unl.edu/rssfeed/

Just knowing the impacts, however, is usually not sufficient for decision makers. Putting those impacts in the context of vulnerabilities and risks allows a decision-making body to determine the significance of a non-response. Two case studies were presented at the meeting that described ways vulnerability assessments have been used. The first was the Hualapai Tribe, which used the Bureau of Reclamation's Drought Program established after the Reclamation States Emergency Drought Relief Act of 1991 (PL 102-250) to conduct a vulnerability assessment of their water supplies, livestock production, wildlife and tourism, and timber. The Hualapai then used the vulnerability analysis to inform their monitoring, response, and mitigation strategies. This was then tested with the NDMC in a drought scenario exercise.

The second case study described Colorado's drought plan and the vulnerability assessment they conducted as part of their planning processes. The assessment focused on six key sectors experiencing the most significant impacts across the state during drought events: recreation, municipal and industry, socioeconomic, environment, energy, and agriculture. Using the NDMC's Drought Impact Reporter, Colorado collected drought impacts by sector and by county. They then created statewide maps based on the data to show where vulnerabilities developed. As Montana continues to work with local authorities on drought planning, it is possible that these vulnerabilities could be incorporated into local plans.

Drought Risk Atlas

NDMC's Drought Risk Atlas (DRA) helps answer the question of how a current drought compares to a previous event. The DRA allows an individual to locate a station closest to their area of interest as well as a cluster of stations with consistent precipitation attributes and see the drought history. It puts an ongoing drought into context with an area's drought history, thereby helping the user visualize and assess risk related to drought.

DROUGHT PLANNING RESOURCES

[*The following section on drought plan features was adapted from the discussion at the meeting and NDMC's website: http://drought.unl.edu/Planning/WhatisDroughtPlanning.aspx*]

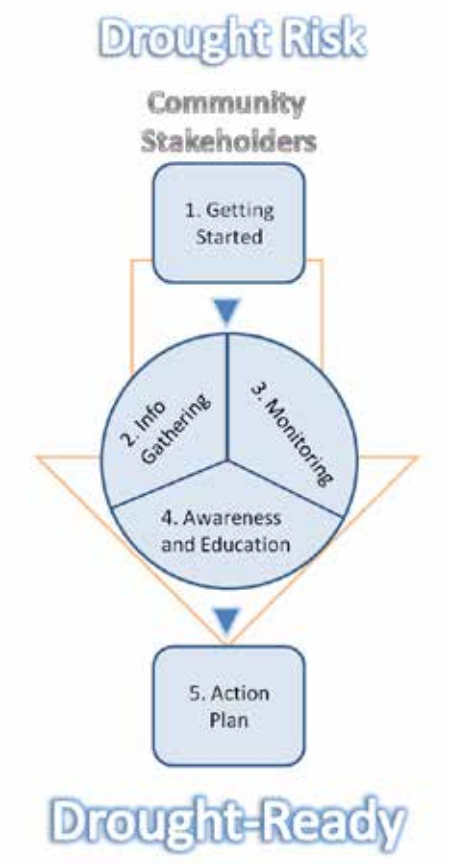
The second part of the meeting focused on steps for creating and implementing a drought plan. The NDMC maintains a searchable database (http://drought.unl.edu/droughtmanagement/Home.aspx) that includes links to drought plans and mitigation actions from states, tribes, cities and municipalities.

A first step in any drought-planning effort is to assemble a team of relevant decision makers and stakeholders. Key questions for the team are:

- "How will drought affect us?" Looking at past drought impacts helps people understand their vulnerability to drought.
- "How will we recognize the next drought in the early stages?" Understanding what data are available and collecting more, if necessary, are key.
- "How can we protect ourselves from the next drought?" The answer to this will vary depending on the enterprise.

After researching impacts, monitoring, and management options, the team can describe how the organization will recognize and respond to drought. In many cases it may be appropriate to identify triggers which would phase in response actions according to the severity of drought.

The team should also consider what the organization can do to reduce long-term vulnerability to drought. For farmers, this could mean management practices that retain water in soil and reduce the need for irrigation. For municipalities, it could be incentivizing more efficient plumbing fixtures, fixing leaks in old pipes or identifying new water supplies. For the federal government, it could be recognizing the interconnections between food, water, and energy, and revamping policy accordingly.



The schematic at left shows the Drought-Ready Communities framework for improving drought preparedness. The process is divided into five areas that were tested in three communities: Nebraska City, NE; Decatur, IL; and Norman, OK.

From the pre-workshop survey

How could you or others in your watershed measure a reduction in impacts?

- Economic assessment.
- Quantify surface water, fishery trends, and agricultural production trends.
- Continue to monitor our resources.
- Soil moisture content monitoring, water monitoring.
- Reduced water use.
- Biomass production/retention, low flow levels in native streams.
- Surveys, community meetings.
- Instream flows and crop yields.
- Measuring streamflow in critical reaches would be one way. Tracking cattle and crop production would be another.
- Impacts could be measured in an economic sense by comparing yield from drought years to non-drought years.
- Statistics related to fisheries, habitat, and agriculture, ie, fish number and size, stream temperatures, soil moisture, irrigation allotments.
- Health studies of livestock and crops in the area in times of drought.
- Landowner surveys of drought impacts, communication between state agencies (e.g. USFS, NRCS, FWP, CDs), comparing to similar watersheds (e.g. crop production yields, well monitoring), photos to monitor land changes.

From the pre-workshop survey

Do you have suggestions regarding ways to improve drought awareness and/or information delivery in the watershed you represent?

- Public awareness is relatively high about the basic effects of drought, but relatively low on measures to adjust to drought.
- Inventory all tools, determine needs, deliver
- Work closely with conservation districts to include most up-to-date resources in their regular customer correspondence/ outreach.
- drought.mt.gov is a good site for the state-wide/ large basin level. At the watershed level, there needs to be key people who understand and have access to the information, and who can get the word out to the local users.
- Locally relevant data will get shared more widely.
- I represent multiple watersheds with varying cultures - there really is no one size fits all.
- I think it would be useful to have a drought awareness presentation at some of the Ag Trade Associations annual conventions.
- On LED signs around town that depict time/temp info, maybe we

Some management options could be implemented in the short term, such as encouraging homeowners to use xeriscaping rather than lawns in dry regions. Other options such as upgrading infrastructure or implementing smart growth development practices can take years. Fortunately, many measures that reduce long-term drought risk also contribute to community health in other ways, so implementing drought risk reduction measures can coincide with other efforts to implement a healthier, more sustainable food and agriculture system, and prepare for other natural hazards.

BIG SKY WATERSHED CORPS MEMBER REPORT OUT AND COMMON THEMES

The Big Sky Watershed Corps (BSWC) members, watershed coordinators, and other participants from the Upper Missouri watersheds (see map below) were asked to use the drought planning methodology presented by the NDMC to consider how those principles might apply to their respective watersheds. This could be either integrated into existing planning efforts, such as a Watershed Restoration Plan, or it could be used to initiate a new planning process. The following section provides a short description of each watershed, opportunities and existing partnerships, and next steps proposed by the BSWC members in their planning processes.

Upper Missouri Headwaters Basin that shows the Big Sky Watershed Corp (BSWC) members and their affiliated watershed groups. The BSWC is an Americorps program that places individuals in Montana watershed communities where they undertake local conservation efforts.

Summary of the unique geography, activities and challenges, and key economic considerations for the BSWC watersheds.

WATERSHED	GEOGRAPHY	ACTIVITIES & CHALLENGES	ECONOMY
Beaverhead River[1]	**Drainage area:** 3,620 sq. mi. (includes Red Rock.) **Median annual volume of water produced:** 592,000 a.ff **Length:** ~ 69 miles	Land use change and management; persistent drought over the past decade	Mostly focused agriculture and recreation interests. ~55% of the land area is federally or state owned
Ruby River[2]	**Drainage area:** 965 sq. mi. **Median annual volume of water produced:** 216,000 a.f. **Length:** ~ 76 miles. Origin in Gravelly and Snowcrest mtns., flowing to confluence with the Beaverhead near Twin Bridges, MT.	Dewatering of tributaries, irrigation conveyance; competing needs between agriculture and fishing sectors. Previous droughts caused wildfire, reduced stream flows, and reduced water quality and soil health	Livestock production primarily on public land in the upper watershed for summer pasture; recreational fishing, with several lodges and two fly rod manufacturers in Twin Bridges. Approximately 1200 residents.
Big Hole River[3,4]	**Drainage area:** 2,500 sq. mi. **Median annual volume of water produced:** 817,000 a.f. **Length:** ~ 150 miles.	In 1997 the BHWC developed Big Hole Drought Management Plan to mitigate the effects of low water quality for fisheries (particularly the Arctic grayling) through a voluntary effort among agricultural operations, municipalities, businesses, conservation groups, anglers, and affected government agencies. The plan has been updated almost every year since, most recently in 2015.	Cattle production; 70% public ownership and 30% private; fishing (blue ribbon trout stream). Fewer than 2,000 year-round residents
Jefferson River[5]	**For portion from confluence of Beaverhead and Jefferson to Missouri at Three Forks: Drainage area:** 2,445 sq. mi. **Median annual volume of water produced:** 120,000 a.f. **Length:** ~ 83 miles.	Maintaining flow to support the ecosystem, and the fishery in particular; changes in land and water uses; aquatic invasive species; coordinating information among the tributaries	More than 57% of the land is private; the rest administered by USFS, BLM, and DNRC Trust lands
Madison River[6]	**Drainage area:** 2,510 sq. mi. **Median annual volume of water produced:** 1,310,000 a.f. **Length:** ~ 183 miles. Origin in Yellowstone N.P., at confluence of Firehole, Gibbon Rivers. Lee Metcalf Wilderness area, the Madison range, and the Big Sky resort communities surround the Madison Valley.	Development; changing land and water use; chronic dewatering; nutrient overload; irrigation conveyance and infrastructure; ice jams; high percentage of absentee landowners	Agriculture; tourism, abundant wildlife and trout fishing.
Gallatin River[7,8]	**Drainage area:** 1,800 sq. mi. **Median annual volume of water produced:** 946,000 a.f. **Length:** ~ 120 miles. Origin in Yellowstone N.P., flowing through Gallatin National Forest, Gallatin Canyon. Passes Big Sky Ski Resort and city of Bozeman. It has 23 major water bodies and 394 miles of streams.	Upper Gallatin: Resort development and water management; no existing drought plan Lower Gallatin: City of Bozeman is working on a drought plan for its municipal water supply; the West Gallatin agricultural users have established a sub-watershed plan to ensure the West Gallatin is not dewatered	Tourism, fly fishing destination (portions of the upper river have been designated as a blue ribbon trout streams); agriculture; unprecedented growth in Bozeman and the region

References:
1. Beaverhead Watershed Restoration Plan: http://www.beaverheadwatershed.org/beaverhead-tmdl-and-watershed-restoration-plan/
2. Ruby Valley Conservation District and Ruby Watershed Council: http://www.rvcd.org/rwc/about-the-rwc
3. http://bhwc.org/
4. http://www.fws.gov/mountain-prairie/pfw/montana/mt3c.htm
5. Jefferson River Watershed Council: http://www.jeffersonriverwc.org/index.html
6. Madison Watershed Assessment Report: http://www.blm.gov/pgdata/etc/medialib/blm/mt/field_offices/dillon/madison.Par.4414.File.dat/report.pdf
7. Upper Gallatin Watershed Restoration Plan: http://www.bluewatertaskforce.org/documents/WFWRP070612_256.pdf
8. Lower Gallatin Watershed Restoration Plan: http://www.gallatin.mt.gov/Public_Documents/GallatinCoMT_WQDReports/Lower_Gallatin_WRP_122214.pdf

Beaverhead Watershed

The watershed boasts significant experience with drought planning and well-established partnerships already, but there were several data and information gaps noted. The need for improvements in snowpack monitoring was noted as critical given the relatively small size of the watershed and need for fairly fine resolution of the data. The possibility of a new SNOTEL site in the Pioneer Mountains was highlighted. Better understanding of both gaining and losing stream reaches was also noted as critical. Improved accessibility of data and information to the public was another area noted as being important, as well as engaging the public and improving local observations through citizen scientist efforts like the Community and Collaborative Rain, Hail, and Snow (CoCoRaHS:) http://www.cocorahs.org/.

Actions: The BSWC member proposed producing a drought memories video, which would be an opportunity to engage residents, record individual experiences and document memories. This project could potentially partner with the historical society. Other ideas expressed were the potential assessment of different approaches to offset grazing through practices such as grass banking; engaging the Beaverhead County Drought Task Force and the Clark Canyon Joint Board to improve coordination; and enhancing access to data such as precipitation, snowpack, streamflows, soil moisture, and seasonal forecast. Finally, the BSWC member would consider assessing ways to improve Beaverhead County stakeholders' understanding of where drought-related data and information come from, and how they are used for decision-making at the state and federal level.

THE BEAVERHEAD has seen persistent drought over the past decade. Photo: http://www.beaverheadwatershed.org/wp-content/uploads/2014/06/IMG_21741-e1403042289380.jpg

THE RUBY RIVER is home to several fly-fishing ldges and two rod manufacturers. Photo: http://cdn.bozemannet.com/images/content/22706_BpIrx_Ruby_River_Fishing_md.jpg

Ruby River Watershed

Challenges noted were the historic mining activities in the area, changing land and water use, chronic dewatering of tributaries, irrigation conveyance, and competing needs between the agriculture and fishing sectors. There is considerable information from the water users association (mapping data; plans; reports), but gaps remain, such as soil moisture and groundwater monitoring; improving understanding of ground-water-surface-water interactions; plant monitoring to evaluate range health; and precipitation and snowpack conditions. Impacts from previous droughts have included wildfire, reduced stream flows, reduced water quality, and soil health.

Actions: The Ruby Watershed BSWC member noted several potential next steps for improved early warning and drought resilience. These included improving public awareness and education, continuing the weekly column in the Madisonian newspaper, considering seasonal forecasting (fall timeframe) to initiate stakeholder discussions and ways to improve proactive decision-making, inviting a reporter from the Madisonian to write drought-related articles during key times of year, conducting mini-workshops to share information with the public and consolidating information into accessible summaries or handouts. The group also discussed conducting a pilot with a high profile local producer and identifying thresholds and trigger dates (e.g. pre-irrigation season; irrigation season; hunting season).

THE BIG HOLE'S STAKEHOLDERS together created a Drought Management Plan to mitigate the effects of low water quality for fisheries (particularly the Arctic grayling) through voluntary cooperative efforts. Photo: http://www.nps.gov/biho/learn/nature/images/BIHO_River_and_BIHO_scene_20090624.JPG

Big Hole Watershed

During the discussion the BSWC member for the Big Hole noted that despite the success of the watershed in collaborating around the Arctic grayling and other issues, there was still a need for education and outreach on being proactive with drought responses prior to the onset of an event. Expanding the Big Hole Drought Plan beyond artic grayling was also noted as a potential need, as well as improving participation from groups and individuals at both the lower and upper Big Hole River watershed. The Big Hole Watershed is unique in that it formed the first watershed group: the Big Hole Watershed Committee (BHWC). The BHWC was formed in 1995 as a response to persistent drought and the potential listing of the Arctic grayling.

Actions: One of the potential ways to improve education and common understanding would be to host a role-playing workshop where stakeholders in the watershed could experience different perspectives by exchanging roles with another sector or group. If conducted, the workshop would ideally work through a set of drought scenarios where difficult decisions and trade-offs regarding water use would be made. Another opportunity discussed was to consider ways to improve drought education, such as conducting talks and presentations at the Big Hole Watershed Committee monthly meetings. This process would also allow assessing community drought perceptions and information needs. Finally, the BSWC member would consider ways to leverage stream restoration projects, such as methods for improving natural water storage, and the rational for expanding the BHWC drought plan beyond the artic grayling.

Jefferson River Watershed

The Jefferson River Watershed Council (JRWC) was created in 1999 by irrigators with the idea to ensure ample water for irrigation while at the same time ensuring enough flows remain to maintain a healthy river ecosystem. In 2010 the JRWC created a Water Restoration Plan primarily to reduce the transport of sediment into the river. The plan also prioritizes issues such as maintenance of base flows, riparian restoration, noxious weed control, flood plain planning, fisheries enhancement, irrigation water management, prescribed grazing systems, protection and maintenance of the local agricultural economy, the need to periodically evaluate the drought management plan, and

THE JEFFERSON RIVER'S DRAINAGE includes more than 800 square miles. Photo: http://water.weather.gov/ahps2/images/hydrograph_photos/twim8/dscn2863.jpg

groundwater characterization and management. The JRWC is also working with USGS to develop modeling to understand the watershed and habitat response to climate variability and change. Important partnerships in the watershed include Montana Fish Wildlife and Parks, Trout Unlimited, Jefferson County Commissioners, Lower Jefferson Watershed Council, and the Montana Bureau of Mines and Geology groundwater assessment.

Actions: Opportunities discussed that could be pursued included assessing whether the drought management plan developed 15 years ago, and updated in 2008, requires another revision. The river is over-allocated and the original plan was created to stop the river from being dewatered. The DNRC and FWP led the process focused on making moderate improvements within existing water rights. These efforts showed progress and that a new process would need to follow a similar course and engage influential stakeholders that could help lead the dialogue and represent various interest groups (e.g., agriculture and Trout Unlimited). The plan does not include the lower Jefferson River, which would need to be assessed in a new revision. The current drought plan does consider coordination with the Big Hole River Drought Plan but it is not clear how information from the Ruby and the Beaverhead Rivers could be used.

Madison River Watershed

The Madison Valley has a large number of agricultural producers as well as abundant wildlife. Trout fishing is extremely popular and a significant contributor to the local economy. Development, changing land and water use, chronic dewatering, irrigation conveyance and infrastructure, ice jams, and a high percentage of absentee landowners are just a few of the challenges in the watershed. There are several key groups and partnerships in the Madison Watershed, including the Madison Conservation District, the Madison River Foundation, Madison Valley Ranchlands groups, Wildlife Conservation Society, The Montana Wetlands Council, Greater Yellowstone Coalition, and Trout Unlimited.

Actions: The Madison Watershed Restoration Plan is still being developed, however the watershed has been extremely active over the years with stream monitoring teams and gathering monthly data at multiple sites. The discussion of next steps to improve drought resilience and early warning focused mostly on integrating these goals with existing efforts like Montana DEQ's goals and the effort to develop a watershed restoration plan for the Madison. For example, dewatering and nutrient overload are big issues and will be exacerbated by drought. How can these things be addressed, leveraging all available programs and mandates, and funding? Other ideas discussed were ways to communicate the economic value associated with fishing, and building better relationships in the watershed by hosting a role-playing workshop to help everyone better understand different perspectives.

Gallatin Watershed

There are many groups and existing partnerships in the watershed actively working towards solving several natural resource and water challenges. There are also several BSWC members working in the Bozeman and Big Sky area. Some of the key groups include the Greater Gallatin Watershed Council, Blue Water Task Force, City of Bozeman and Gallatin Local Water Quality Districts, One Montana, Gallatin Conservation District, Jack Creek Preserve Education Center, Gallatin Valley Land Trust, Trout Unlimited Montana Water Project, Montana Aquatic Resources Services, and the Montana State University Water Center and Researchers. Given the

size and the diverse features of the Gallatin Watershed the discussion was divided into the Upper and Lower Gallatin Watershed.

Upper Gallatin Actions: There is little agriculture in the upper watershed and the primary issue has been related to resort development and water management. While there have been a number of efforts focused on water quality, there has not been as much attention to the management of water quantity. There is no existing drought plan for this part of the watershed.

Key partners to engage in the water management issue would be the board for the Blue Water Task Force, Yellowstone National Park, USFS, Big Sky Ski Resort, golf courses, and state agencies. A first approach could be to focus on water conservation by improving outreach and educational activities. This could include identifying incentives to engage people, such as holding a competition between various areas to support conservation using EPA's H2Otel Challenge (http://epa.gov/watersense/commercial/challenge.html). A potential local resource and model for water efficiency efforts could be the City of Bozeman and its efforts to roll out the hotel challenge in the Fall of 2015.

Lower Gallatin Actions: The Lower Gallatin covers approximately 997 square miles and includes both urban and agricultural stakeholders. The Lower Gallatin sub-watershed starts at the headwaters of Hyalite Creek and ends at the confluence of the Gallatin, Madison, and Jefferson rivers. Potential activities discussed at the meeting include: the City of Bozeman is working on a drought plan for the city's municipal water supply; the West Gallatin agricultural users have established a sub-watershed plan to ensure the West Gallatin is not dewatered; and there was a suggestion to continue working on sub-watershed drought plans for other parts of the Lower Gallatin, such as the East Gallatin. Another potential idea to consider was to use the Lower Gallatin Restoration Plan and 319 funding to get irrigators involved in drought-related work. Public outreach and participation was another area that needs attention. For example, establishing a volunteer monitoring network (CoCoRaHS) was one way to improve public participation in monitoring for drought. Another approach was to improve the way drought is framed by describing it in conversational terms (e.g., drinking water; fire). For the Lower Gallatin it was noted that a successful public outreach campaign would need to resonate with both urban and rural residents.

THE GALLATIN originates in Yellowstone National Park and flows north to Bozeman, requiring drought planning which includes wilderness, rural and urban interests. Photo: http://commons.wikimedia.org/wiki/Category:Gallatin_River#/media/File:GallatinRiver1997.jpg

Workshop participants form the Missouri headwaters met for two days in Bozeman, Montana in March 2015.

POST-WORKSHOP SURVEY

Following the workshop, the participants received a survey asking their opinions of the workshop, and what were the most important things they learned as a result of the meeting. Approximately 60% filled out the survey. When asked about the most important ideas, resources, or information that they took away from the workshop, participants mentioned learning about the large amount of useful information and resources that exists for drought monitoring and management, learning about processes for drought planning, learning who they can work with as partners, and learning more about the other individual watershed councils and issues they are facing locally.

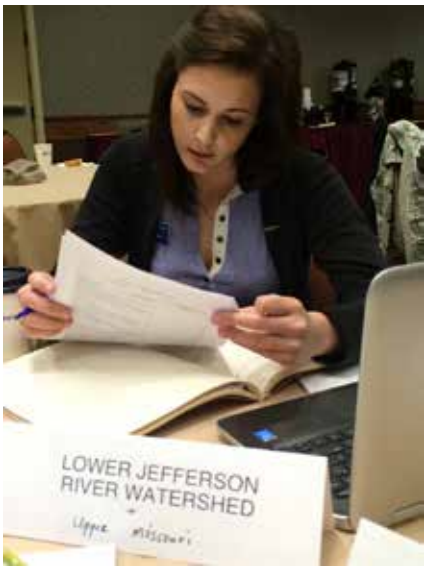
Some sample comments:

- "There is a large amount of useful information, but very little in place at the local level for real time stream flow data & coordination between the stakeholders. In addition to more support by the state for stream gages & coordination between resource agencies and other stakeholders there needs to be more time spent on identifying and implementing Best Management Practices which could be implemented to conserve or reduce water use. Water rights & money will run over any plan developed by resource groups not coordinating completely with water right holders. Most of the watershed groups in place have young inexperienced staff working on very small budgets. Not a recipe for a successful implementation of a drought management plan implementation when a major drought hits."

- ✦ "Through this workshop, I realized how important it is for our community to develop a drought/water plan. I really enjoyed brainstorming the first steps of developing a plan on the second day. I also enjoyed networking with colleagues and others involved in drought planning."
- ✦ "Starting to think about drought as a human and economic problem, not just a climate/environment problem."
- ✦ "Interesting to see both similarities and differences across the watersheds in the issues they are facing and things they will need to deal with in their drought plans."

About 60% of the respondents said that, after the workshop, they were able to identify at least one course of action that they could take to minimize future drought risk in their watersheds, including stream restoration and starting a drought plan. When asked about steps that they hoped to take in their watershed over the next six months, to minimize future drought risk, participants listed the following:

- ✦ "Complete our watershed restoration plan to include potential projects that would result in natural water storage."
- ✦ "In the next six months, I hope we can start a conversation about drought among residents and other organizations in the watershed through education programs."
- ✦ "Improve data resources and accessibility. Possibly write a local drought plan."



Studying planning materials for the Lower Jefferson.

- "The JRWC drought management coordinator working with the FW&P's will increase their initiative to work closer with the watersheds in the Ruby, Beaverhead and the Big Hole."
- "Facilitate meetings on beaver mimicry structures as a tool to level the hydrograph and raise the water table."
- "We just had a planning meeting in one of my watersheds and discussed projected water supply conditions for the upcoming season. We also discussed with the major water users how we could better coordinate diversions and storage releases to meet needs and maintain minimum flows in the river."
- "Over the next six months, I would like to have discussions with community leaders about developing a plan, finding a facilitator for this process, and a funding source."
- "Education is the biggest arena I can effect change with."
- "Discuss with others to see dollar values on ranching and fishing in Madison."
- "Have already brought the subject of drought planning up as agenda item to our local landowners group. Will likely have a meeting in the community on this subject in next six months."
- "Actual implementation of water management projects in response to drought triggers."

When asked about more training, two-thirds of respondents said they would like to learn more about other existing drought plans. About half said they would like to learn more about tools and monitoring and forecast products such as snowpack, precipitation, temperature, streamflow and streamflow forecasts, fire risk assessment, seasonal climate prediction, etc.; vulnerability assessment; and communication techniques. Their preferred means of receiving this information were through webinars, short videos, and in-person workshops.

SUMMARY AND CONCLUSION

The meeting brought the watershed communities together to learn more about drought planning tools; NDMC and NIDIS; exchange information across state and federal agencies working in the basin (e.g. MT DEQ, EPA, NRCS, BLM, USFWS, USFS); and to learn more about the challenges, opportunities and existing work and activities occurring across the Upper Missouri Basin. Tools such as NDMC's Drought Risk Atlas and Drought Impact Reporter were demonstrated, while the watershed participants and community stakeholders shared their successes as well as their concerns for dealing with drought. Several themes emerged from the meeting:

1) What could be done in the watersheds recognizing all of the work already underway;

2) How to leverage, integrate and build on existing successful efforts such as watershed restoration plans (WRPs) many of the watersheds have already developed;

3) Developing and enhancing collaboration with active NGO partners, state agencies, universities, and private citizen interests.

Central Activities for the Big Sky Watersheds

- ✦ Develop a Missouri Basin Headwaters Plan: Working through the BSWC members and watershed coordinators, develop a plan that integrates the Upper Missouri River watersheds to foster early warning and proactive planning for drought
- ✦ Watershed groups assess ways to integrate existing water planning concepts into the discussion of drought early warning and overall drought resilience for their watersheds
  - -- For example: Use the process of Watershed Restoration Planning and 319 funding to involve stakeholders (e.g. irrigators) in drought-related planning.
  - -- Assess models and or mechanisms that could support sub-watershed planning efforts like the West Gallatin plan.
- ✦ Conduct drought scenario workshops. These workshops would primarily focus on exchanging perspectives, and assessing triggers, data gaps and coordination needs within as well as among watersheds
- ✦ NDMC, NIDIS, and DNRC with the BSWC members and watershed coordinators continue the dialogue through webinars and in-person meetings to exchange information on drought planning (e.g. NDMC's Managing Drought Risk on the Ranch), improving understanding of season climate forecast, and other topics of interest.•
- ✦ For watersheds with large resorts and rapid urban development, support water conservation efforts like those the City of Bozeman are implementing.

RESOURCES

National Integrated Drought Information System
http://www.drought.gov/drought/

National Drought Mitigation Center
http://drought.unl.edu/

Montana Department of Natural resources and Conservation
http://dnrc.mt.gov/

U.S. Drought Monitor
http://droughtmonitor.unl.edu/Home.aspx

Drought Risk Atlas
http://droughtatlas.unl.edu/

Drought Impact Reporter
http://droughtreporter.unl.edu/

Western Regional Climate Center
http://www.wrcc.dri.edu/

Montana Climate Office
http://www.climate.umt.edu/

Montana's Current Water Supply and Moisture Conditions by County
Montana Surface Water Supply Index
http://drought.mt.gov/default.aspx

USDA Montana State Farm Service Agency
http://www.fsa.usda.gov/FSA/stateoffapp?mystate=mt&area=home&subject=landing&topic=landing

USDA Forest Service Active Fire Maps
http://activefiremaps.fs.fed.us/activefiremaps.php

Greater Gallatin Watershed Council
http://greatergallatin.org/

Blue water Task Force
http://www.bluewatertaskforce.org/

Gallatin Local Water Quality District
http://www.gallatin.mt.gov/Public_documents/gallatincomt_wqdpages/lwqd

One Montana
http://www.onemontana.org/

Gallatin Conservation District
http://www.gallatincd.org/

Jack Creek Preserve Foundation
http://www.jackcreekpreserve.org/

Gallatin Valley Land Trust
http://www.gvlt.org/

Trout Unlimited Western Water Project
http://www.tu.org/tu-programs/western-water

Montana Aquatic Resources Service
http://montanaaquaticresources.org/

Montana Water Center
http://www.montanawatercenter.org/

Madison Conservation District
http://madisoncd.net/

Madison Watershed Partnership
http://madisoncd.net/madison-watershed-partnership/

Madison Stream Team
http://madisoncd.net/category/madison-stream-team/

Madison Valley Ranchlands Group
http://www.madisonvalleyranchlands.org/

Nature Conservancy Montana Chapter
http://www.nature.org/ourinitiatives/regions/northamerica/unitedstates/montana/index.htm?intc=nature.tnav.where.list&src=sea.AWP.PR0.CP215.AD151.KW5845.MT1.BU930&nst=0&adpos=1t1&creative=81534812438&device=c&matchtype=b&network=g&gclid=CMCfyPKgvcYCFQ-maQod5uYAqw

Greater Yellowstone Coalition
http://www.greateryellowstone.org/

Madison Farm to Fork
http://www.madisonfarmtofork.com/

Ruby Valley Conservation District
http://www.rvcd.org/

Ruby Habitat Foundation
http://www.rubyhabitat.org/default.php.html

Gravelly Collaborative
http://gravellycollaborative.org/

High Divide Collaborative
http://www.craigheadresearch.org/high-divide1.html

Jefferson River Watershed Council
http://www.jeffersonriverwc.org/

Centennial Valley Association
http://www.centennialvalleyassociation.org/

Beaverhead Watershed Committee
http://www.beaverheadwatershed.org/

Montana Association of Conservation Districts:
http://macdnet.org/

Montana Watershed Coordination Council:
http://www.mtwatersheds.org/